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A SADAP Investigation of EXOSAT/HEAO-2 Temporal and Spectral Signatures of Black Hole Accretion

1 INTRODUCTION

The major objective of this investigation was to investigate the possible characteristic signatures of accretion onto black holes in x-ray binary systems. The goal was to find possible discriminators between black holes and neutron stars from their time variability and (possible) spectral/temporal variability alone. If this could be achieved, it would open the way for many interesting new problems: from the origin and evolution of compact stellar remnants to the physics of accretion onto black holes.

The study made use of (primarily) EXOSAT data on three different x-ray binaries: a very likely black hole system (Cyg X-1), a likely neutron star system (V0332+53) and an indeterminate system (GX339-4). The study concentrated on the development of analysis methods rather than the full data sets from these sources themselves; follow up analysis of the full data on these and other sources is contemplated for a future investigation. The development of the analysis methods, in turn, concentrated on the application of a new technique, the method of strange attractors, to time-series data.

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2 THE DATA SETS

The data used for this project were in fact derived from the EXOSAT satellite. The HEAO-2 data will be incorporated at a later stage. EXOSAT data were obtained from the ME (Medium Energy) detector for the sources Cyg X-1, V0332+53 and GX339-4. Approximately 10^4 sec of data were obtained for each source. The data sets were not all of uniform quality (e.g. background levels) or time resolution, since the detector configurations used in the original observations differed.

3 ANALYSIS METHODS

The primary method used was derived from the discussion of Nicolis and Nicols (1984). In this mehod, the time series data are searched for correlations in a phase space of (effectively) mnumber of occurences of data with a given time binning. The 'trajectory' of this correlation defines the 'strange attractor'. The dimensionality of the system, in a fractal sense, can be determined from the slope of the plot of the correlation integral vs. the radius in phase space over which the correlation is done. A major effort was spent on incorporating methods for speeding up the correlation software, such as by using the "Box-assisted" correlation method of Theiler.

4 RESULTS

Light curves of the data sets from EXOSAT were plotted and the general variability established for each data set. Rudimentary tests for the variability were run so that the source variability could be established first with the conventional measures of mean, variance and power spectrum. The correlation search, using the optimized methods, were then run. Tests were derived to investigate the effects of the counting statistic noise on the results: the general source variability characteristics were simulated in a general simulation in which counting statistics could be 'turned on and off' for comparison of the results. The effect on the strange attractor of the model were noted and applied to the analysis of the real data.

The results of the analysis of the real source data are still under review, and the character of the possible attractors in the data sets still being investigated. Comparisons of the results with those of the attractor analysis of Lochner et al (1988) for Cyg X-1 are being made. A detailed report of this work (Covault and Grindlay 1989) is being submitted for publication.

5 CONCLUSIONS

The application of strange attractor methods to the characterization of time variability in black hole candidates appears promising and worthy of further study. Results obtained thus far suggest that the effects of counting statistics are important. The possible high order dimensionality of the attractor for Cyg X-1 mentioned by Lochner et al would, if confirmed in our final analysis, indicate a turbulent emission region which could provide a black hole signature.

6 REFERENCES

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